Global Aerosol Modeling at NCEP:
A new capability by transitioning NASA research to operations

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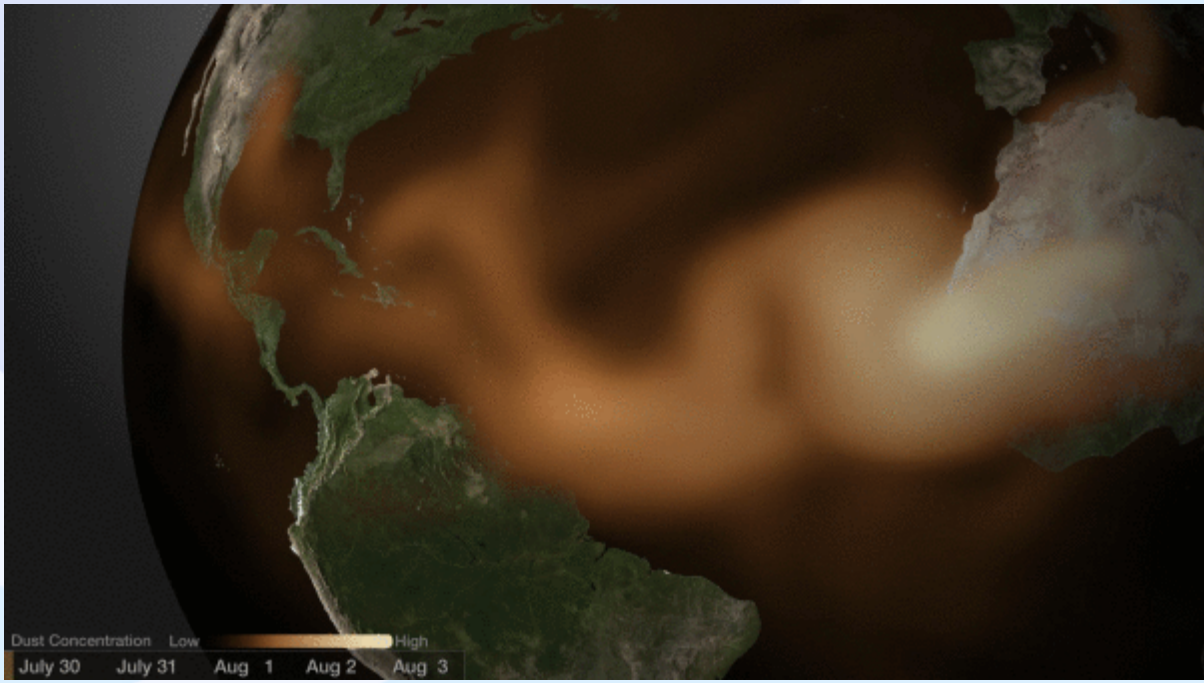
Trans-Atlantic Sahara dust

Nightly News | July 31, 2013
Massive dust storm sweeps over Atlantic

The Saharan Air Layer, a burst of dust, could possibly suppress this year's hurricane season. NBC's Brian Williams reports.



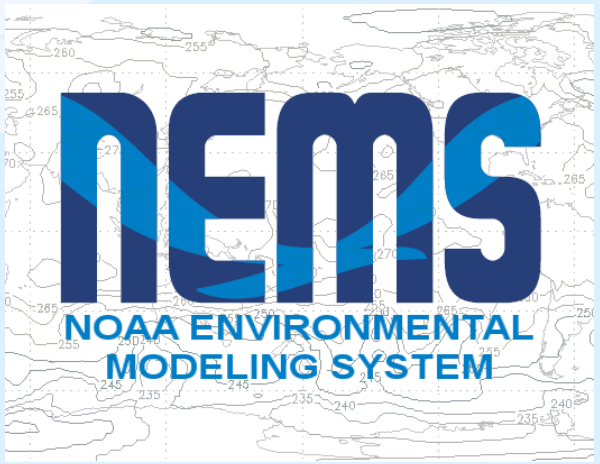
WKRG (CBS at Mobile, AL) : Saharan dust moves across the Atlantic (Aug 8)
KSAT (San Antonio, TX): Saharan dust cloud over San Antonio irritates residents (Aug 9)

While the impact of dust on hurricane is yet to be determined, the long range dust transport and its impact on air quality and public health is clearly shown.

Global aerosol prediction at NCEP

NEMS GFS Aerosol Component (NGAC)

- Successful example of transitioning NASA research to NCEP, supported by NASA Applied Sciences Program
- NCEP's global in-line aerosol forecast system
- Build upon NOAA Environmental Modeling System (NEMS), a common modeling framework using Earth System Modeling Framework (ESMF)
- Provide 5-day dust-only forecast since 2012
- Model Configuration:
  - Resolution: T126 (~ 1°x1°) L64
  - AGCM: NCEP's NEMS GFS
  - Aerosol: GSFC's GOCART

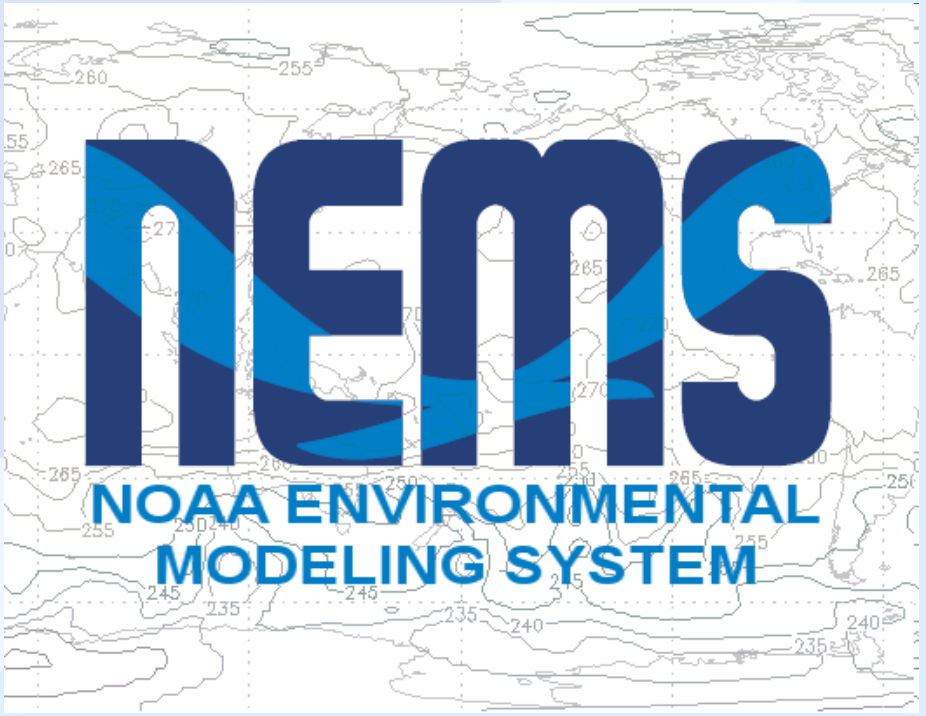


ESMF Earth System Modeling Framework

Multi-agency collaborations toward developing global aerosol forecasting system at NCEP

NCEP EMC team

Jun Wang (aerosol modeling, project POC)
Mark Iredell (NEMS team lead)
Shrinivas Moorthi (physics)
Yu-Tai Hou (radiation-aerosols)
Henry Juang (dynamics)
Hui-Ya Chuang (post-processing)
Weiyu Yang (ESMF infrstructure)
Perry Shafran (verification)
Downstream applications (Jeff McQueen)



NCEP Collaborators

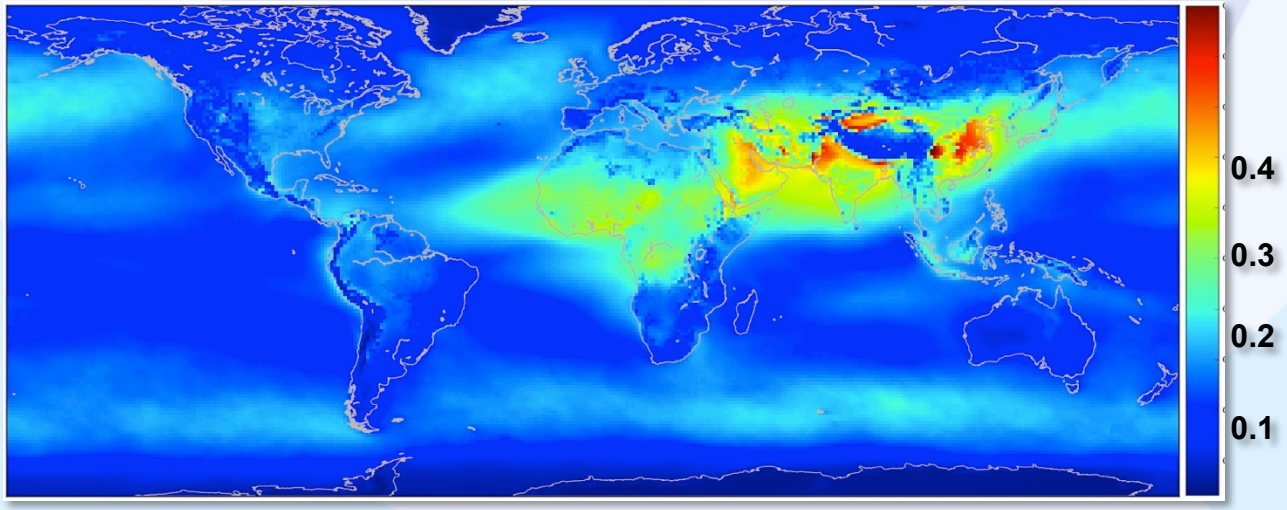
NASA/GSFC: Arlindo da Silva, Mian Chin, Peter Colarco, Anton Darmenov, Donifan Barahona
NESDIS/STAR: Shobha Kondragunta
Universities: Sarah Lu, Qilong Min, Sheng-Po Chen (University at Albany, SUNY)
Xiaoyang Zhang (South Dakota State University)

Why include aerosols in the predictive systems?

- Improve weather forecasts and climate predictions by taking into account of aerosol effects on radiation and clouds
- Improve assimilation of satellite observations by properly accounting for aerosol effects
- Provide aerosol (lateral and upper) boundary conditions for regional air quality predictions
- Produce quality aerosol information that address societal needs and stakeholder requirements, e.g., UV index, air quality, ocean productivity, visibility, and sea surface temperature retrievals.

Semi-empirical satellite model for solar power

Radiative transfer model (quasi physical) + cloud modulation (largely empirical)
Solar power product: 10 km hourly (standard); 1km ½ hourly (enhanced)

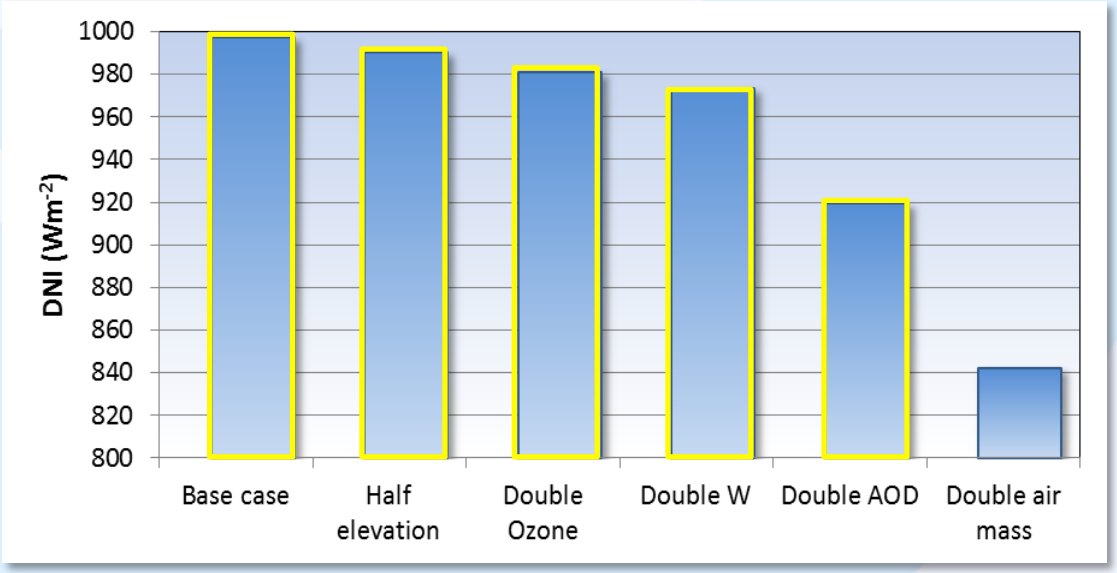


AOD

W Preciptable water

O_3 Ozone

H Altitude



Richard Perez (SUNYA) and Tom Hoff (Clean Power Research)

Global aerosol prediction at NWP centers

- Aerosol modeling, traditionally serving regional air quality and climate communities, has seen rapid development at several operational NWP centers over the last few years
- Operational aerosol forecasts are now available from several operational and research NWP centers
- Aerosol prediction systems are built upon modeling/assimilation methodologies already in place for the meteorological systems.
  - NRL: NAAPS, driven by NOGAPS
  - ECMWF: MACC, IFS coupled with LMD
  - UKMO: MetUM with the Hadley Centre dust scheme
  - GMAO: GEOS-5, GEOS-5 AGCM coupled with GOCART
  - NCEP: NGAC, NEMS GSM coupled with GOCART

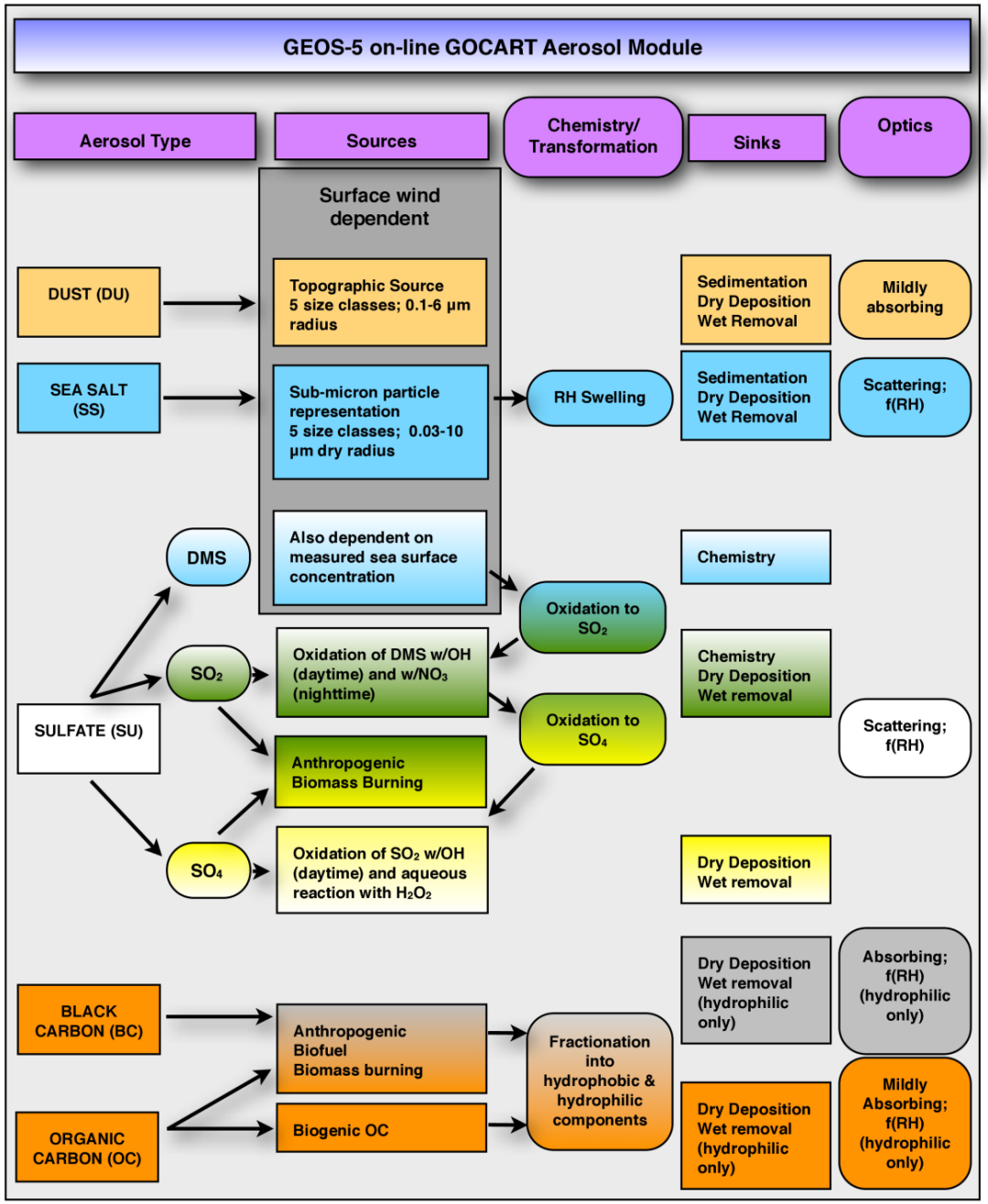
GOCART in different AGCMs: NCEP-GSFC collaborative R2O project

GOCART Module

In-line chemistry advantage

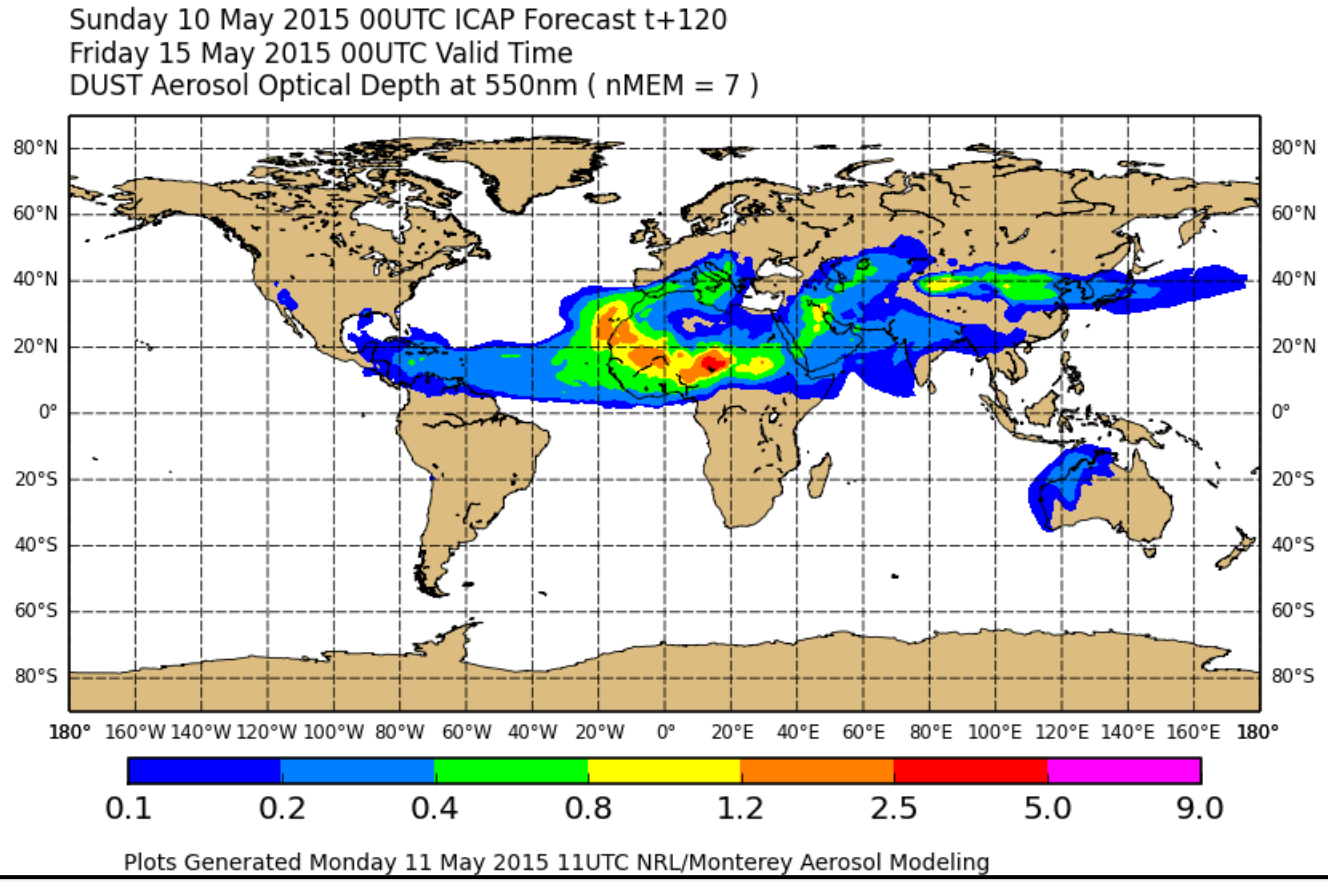
- Consistency: no spatial-temporal interpolation, same physics parameterization
- Efficiency: lower overall CPU costs and easier data management
- Interaction: Allows for feedback to meteorology

GOCART diagram provided by Peter Colarco (GSFC)



Multi-Model Aerosol Ensemble

International Cooperative for Aerosol Prediction (ICAP) multi-model ensemble.
Dust AOD from 7 members (BSC, ECMWF, GMAO, NCEP, NRL, JMA, and UKMO)



ICAP is a global aerosol forecasting working group for aerosol forecast centers and data providers. NCEP leverages collaborations with other recognized world experts in operational aerosol forecasting

Looking forward …..

Ongoing aerosol modeling activities	Program facilitating R2O
Enable global short-range multi-species aerosol prediction (Q1Y16)	Joint Center for Satellite Data Assimilation (JCSDA)
Provides a first step toward an operational aerosol data assimilation capability at NOAA	JCSDA
Allows aerosol impacts on medium range weather forecasts to be considered	NWS Next-Generation Global Prediction System (NGGPS) R2O
Allows NOAA to explore aerosol-cloud-radiation interaction in the Climate Forecast System (CFS)	CPO MAPP-Climate Test Bed (CTB)
Provides lateral aerosol boundary conditions for regional air quality system (Q4FY15)	NWS National Air Quality Forecast Capability (NAQFC)

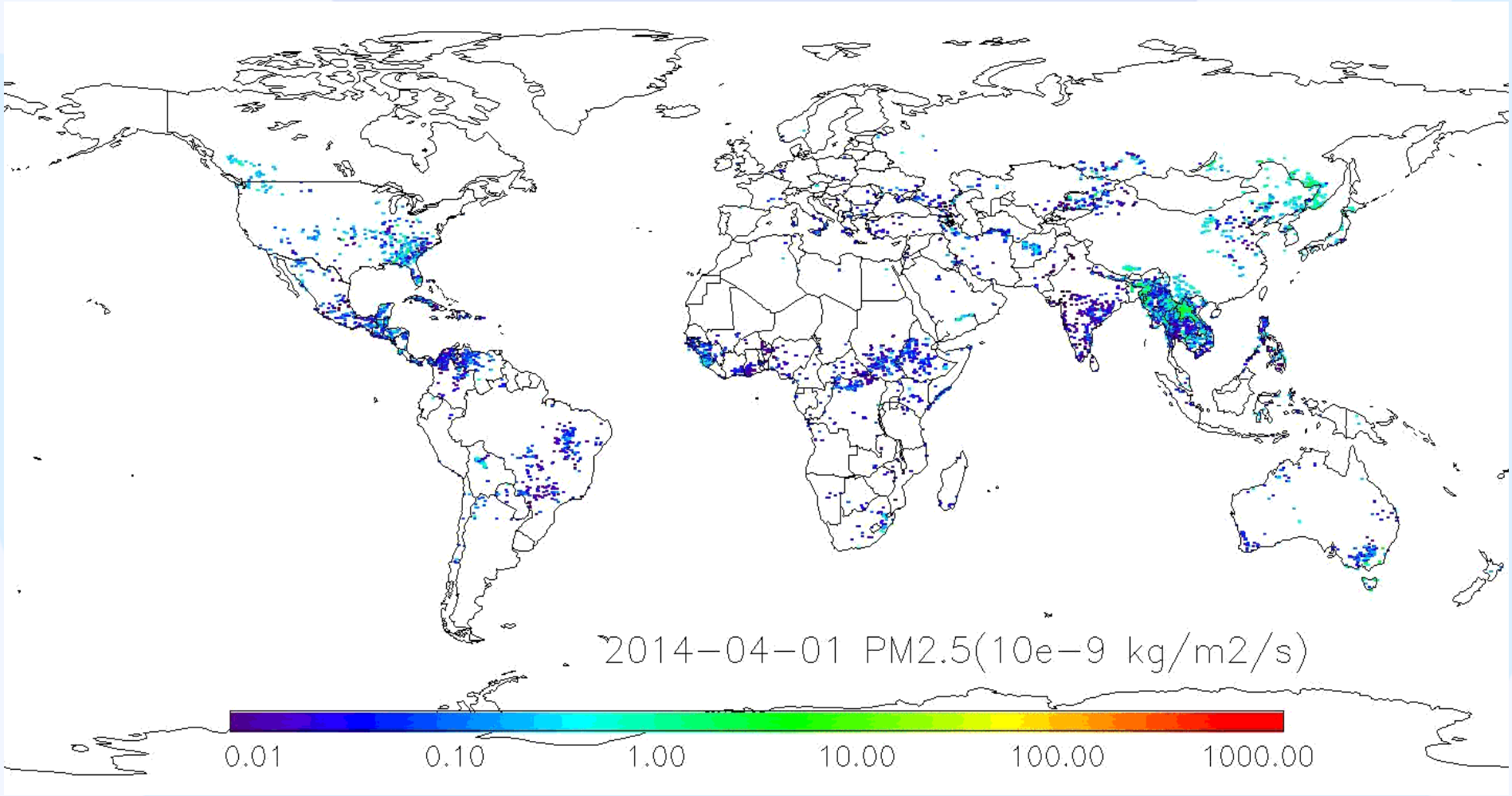
JSDI Project: *Global Aerosol Forecasting at NCEP using Satellite-based Smoke Emissions*

NESDIS/STAR: Shobha Kondragunta, Xiaoyang Zhang[#]
NCEP/EMC: Sarah Lu[*], Jun Wang, Jeff McQueen
GSFC/GMAO: Arlindo da Silva
ARL: Hyun Kim

- Multi-agency collaborative efforts to develop the near-real-time smoke emissions (GBBEPx), funded by JCSDA Science and Development Implementation (JSDI)
- The implementation of GBBEPx by NESDIS enables NCEP to upgrade NGAC for multi-species forecast (Q1FY16)
- The multi-species prognostic capability provides a first step toward aerosol data assimilation and aerosol reanalysis
- Efforts are underway to develop the DA capability at NCEP (a NCEP-STAR-GSFC-SUNYA collaborative project funded by JCSDA)

*: now at SUNYA
#: now at SDSU

Temporal and Spatial Variation in Fire Emissions from GBBEPx

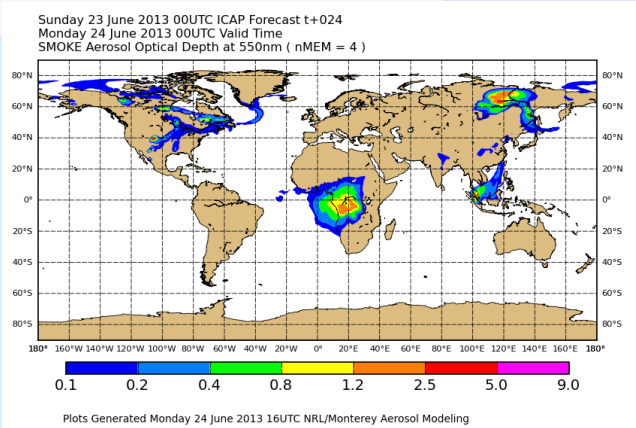


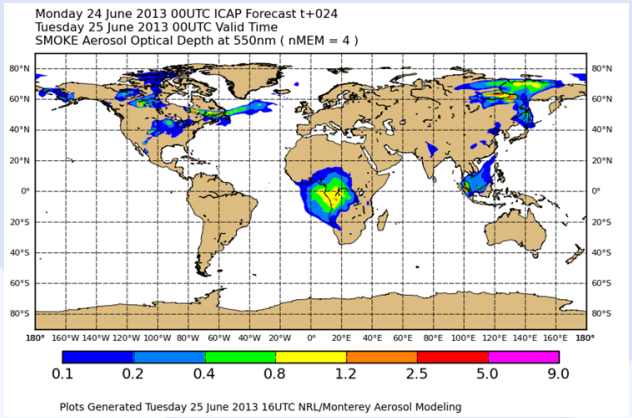
GBBEPx: Global Biomass Burning Emissions Product from Geo (NESDIS's GBBEP) and Polar (GMAO's QFED)

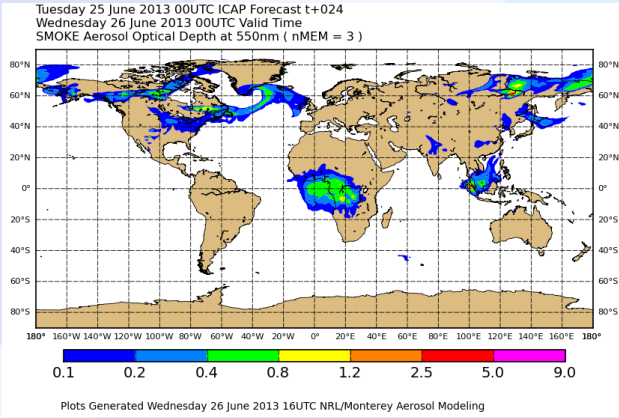
Shobha Kondragunta (NESDIS/STAR)

NGAC simulations using GBBEPx

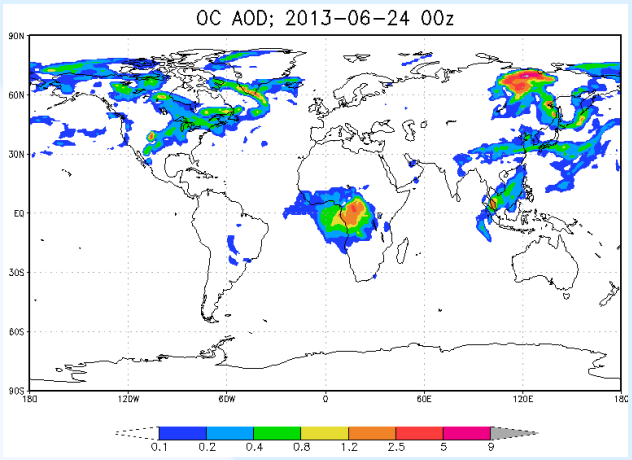
ICAP global ensemble from NRL, ECMWF, GMAO, and JMA

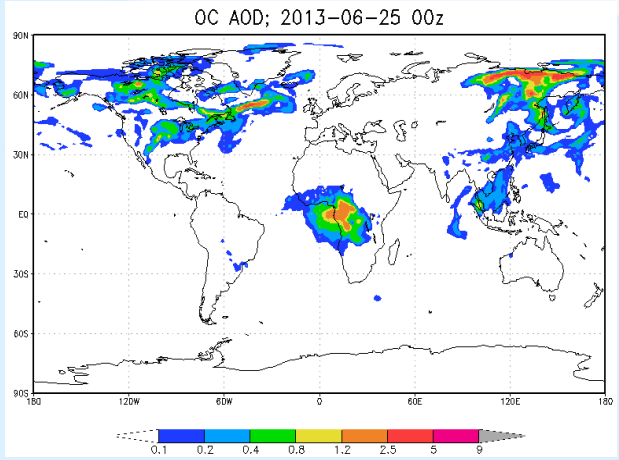


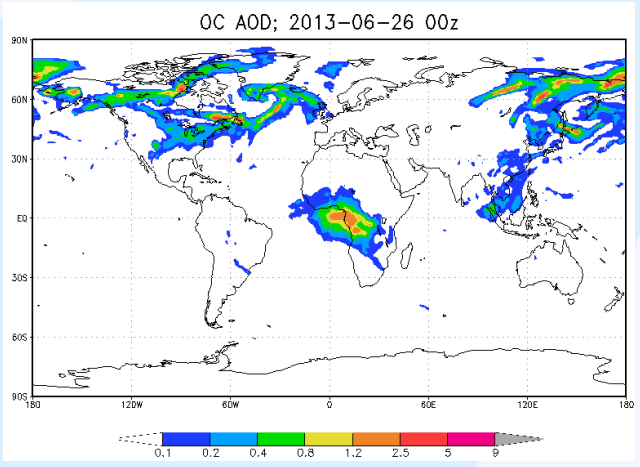




NGAC OC 24hr forecast for Jun 24-26 2013





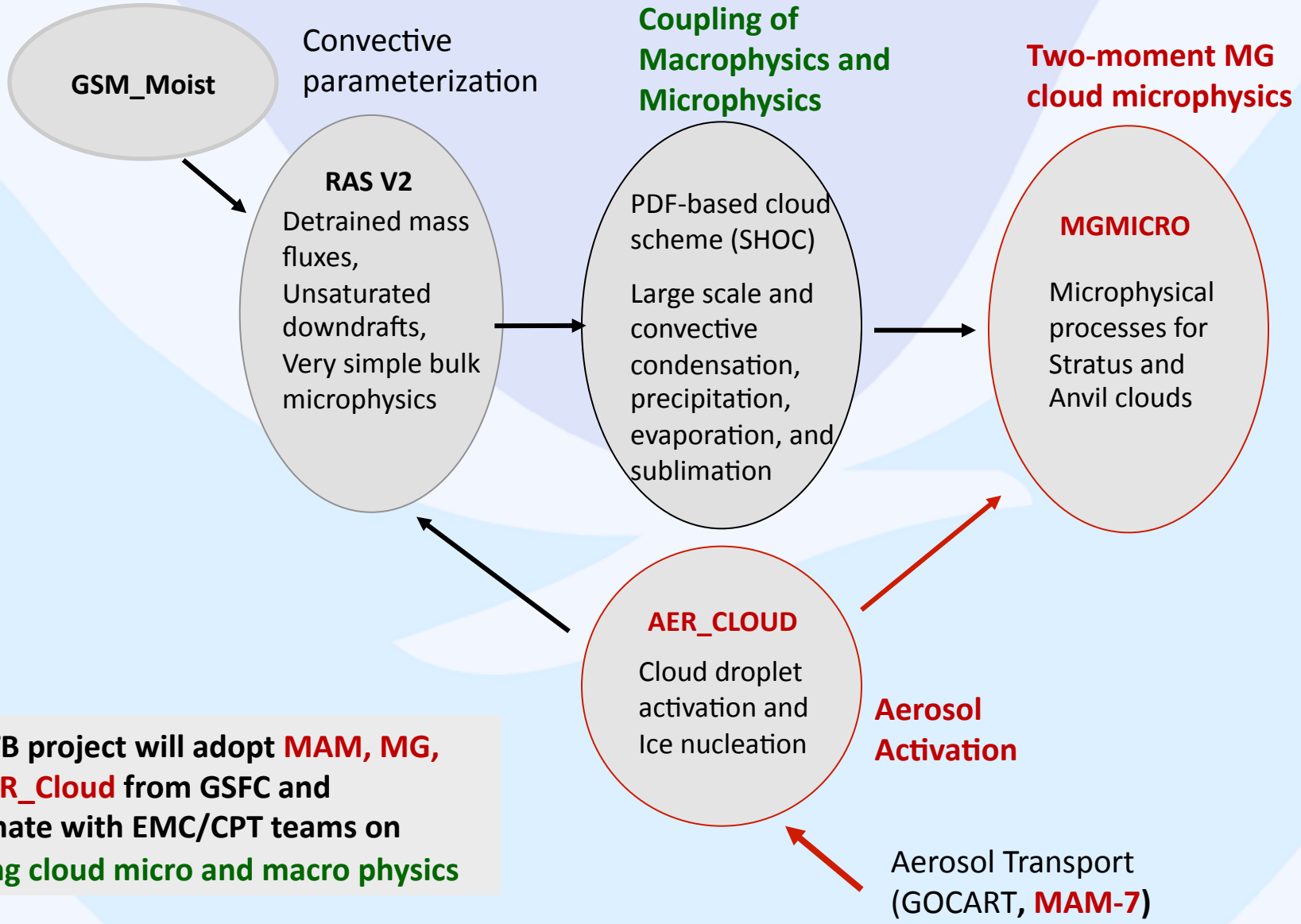


MAPP-CTB Project: *Improving Cloud Microphysics and Their Interactions with Aerosols in the NCEP Global Models*

SUNYA: Sarah Lu, Qilong Min, Sheng-Po Chen
GSFC/GMAO: Arlindo da Silva, Anton Darmenov, Donifan Barahona
NCEP/EMC: Yu-Tai Hou, Shrinivas Moorthi, Fanglin Yang, Jun Wang

- Multi-agency collaborative efforts to improve the representation of aerosol processes, cloud microphysics, and aerosol-cloud-radiation interaction in NCEP global models
- Proposed physics upgrade: adapting GSFC's physically-based aerosol and cloud microphysics package (which in turn is based on NCAR CAM5)
- This project contributes toward the development of advanced physical parameterization suite in NEMS, and is closely aligned with the NWS R2O Initiative

Adopting GEOS-5 aerosol-cloud package



This CTB project will adopt MAM, MG, and AER_Cloud from GSFC and coordinate with EMC/CPT teams on coupling cloud micro and macro physics

Concluding Remarks

- The global aerosol modeling capability at NCEP has been established through close collaborations among NCEP, NASA GSFC, NESDIS STAR, and universities
- The research-to-operation is accomplished by:
  - Concurrent code management via version control: code development are committed to NCEP code repository and all tests are based on NCEP parallel infrastructure
  - Utilization of Earth System Modeling Framework (ESMF) in NEMS
  - Operational requirements and constraints clearly defined by NCEP
  - Continued engagement to ensure close communication and coordination between R and O throughout the transition (Not just R handoff to O)
- Multi-agency partnership arrangements are needed to ensure sustainable system development at NCEP.
- The transition of research capabilities to operational implementation has been facilitated by applications oriented programs (e.g., NASA ASP, JCSDA, and MAPP-CTB)

Thanks.

Questions and Comments?